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STATUS REPORT ON THE SOLID
WASTE REDUCTION UNIT (SWARU)
DIOXIN TEST PROJECT AT
HAMILTON, JANUARY 1984.

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GOVERNMENT DOCUMENTS

STATUS REPORT ON THE SOLID WASTE REDUCTION UNIT (SWARU)

DIOXIN TEST PROJECT AT HAMILTON

JANUARY 1984

ONTARIO MINISTRY OF THE ENVIRONMENT

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TABLE OF CONTENTS

	<u>Page</u>
1.0 HISTORY OF SWARU.....	1
2.0 THE DIOXIN PROBLEM.....	2
3.0 THE TEST PROGRAMME.....	3
3.1 Introduction.....	3
3.2 Objectives.....	4
3.3 Field Tasks.....	5
3.4 Inspection And Cold Tests.....	5
3.5 Combustion Tests.....	6
4.0 DIAGNOSTIC TESTS FOR DIOXIN AND FURAN FORMATION.....	8
5.0 COMBUSTION TEST RESULTS.....	8
6.0 DIAGNOSTIC (DIOXIN) TEST RESULTS.....	10
7.0 RECOMMENDATIONS.....	11
8.0 PROPOSED CONDITIONS OF OPERATION.....	11
9.0 FUTURE ACTIONS.....	12

1.0 HISTORY OF SWARU

The Solid Waste Reduction Unit (SWARU) is a municipal facility for incinerating commercial and residential wastes. Building of the unit was started in 1969 and was commissioned by the City of Hamilton in 1972. Designed by Gordon Sutin Consultants, it has a water-walled boiler unit which was included in the design to serve a dual function. It was hoped that the steam produced could be sold for heating purposes to occupants of an industrial complex which was anticipated to be built in the immediate neighbourhood. The boiler also served to reduce the temperature of the flue gases to a level suitable for the efficient operation of the electrostatic precipitator used to remove fly ash from the stack gas. Contrary to expectations, however, the demand for heat did not develop. In consequence, the major part of the steam produced was condensed, while a small portion was used to heat the facility.

When the Regional Municipality of Hamilton-Wentworth was formed, it took over responsibility for the operation of SWARU. In February 1978 Tricil Ltd. contracted to operate SWARU as part of a wider waste management system for the Region. In order to make use of some of the steam produced, a four-megawatt steam turbine-generator was installed in 1982. This generator, which was jointly funded by Tricil and the Ministry of Energy, was designed to produce electricity (14 million kilowatt hours annually), some two thirds of which would be sold to Ontario Hydro.

Since the plant began operating in 1972, a large number of complaints has been received from local residents concerning the fall-out of large particulates in the vicinity of SWARU. Numerous attempts have been made to improve the operation of the units with respect to the fall-out problem as well as other operational and in-plant conditions.

In 1976, following a consultant study by SNC, improvements were made to the waste handling system and other in-plant equipment to reduce fire and safety hazards and to provide dust control within the unit and to improve operation of the facility. These modifications cost \$487,000 of which the Ministry of the Environment provided \$300,000.

Attempts to improve the control of stack emissions of particulate matter were made when two studies were commissioned, one in 1979 by the Regional Municipality, the other in 1981 by Tricil Ltd. These and other studies and reports produced by equipment suppliers led to changes to the electrostatic precipitator at a total cost of \$250,000. The Ministry contributed \$105,000 to these improvements.

Although these changes and modifications to the incinerator feed system (instituted by Tricil Ltd.) improved the emissions of particulate material, problems associated with large particulate fallout persisted.

2.0 THE DIOXIN PROBLEM

In 1982, within a Ministry programme for testing incinerators for dioxin emissions, three stack gas tests were undertaken at SWARU and analyzed for dioxins and furans. Each of these tests was made by standard methods and covered a 24-hour period. The outcome of these tests indicated that the emissions from SWARU resulted in ground level concentrations in excess of the Ministry's provisional guideline for dioxins and furans. The other incinerators tested in the same programme met the provisional guidelines which were designed for the protection of public health and safety. The results of these studies became available and were released in February 1983.

In order that possible health effects due to the presence of dioxins could be avoided, the Regional Municipality (at the request of the Ministry of the Environment) restricted operation of SWARU to four days per week and set a limit of 400 tons per working day to the rate of refuse- derived fuel fed to the incinerator. This has been the working capacity of the incinerators since that time.

In April 1983 an investigation was started, aimed at determining how SWARU could be operated while maintaining dioxin emissions within the provisional guidelines. Subsidiary objectives to this study were to eliminate problems due to the emissions of particulate matter and smoke. Contracts for this study were let to the Ontario Research Foundation (ORF) and Envirocon Eastern Ltd. (Envirocon).

ORF was responsible for sampling of stack gases for dioxins, furans, particulates and chlorinated hydrocarbons, while Envirocon was to conduct combustion studies and to monitor operational parameters during the dioxin tests. The object of the combustion studies and the responsibility of Envirocon was to establish conditions under which the emissions of dioxins, smoke, hydrocarbons and particulates could be minimized. These tests were conducted during April and May 1983. Analyses of the collected samples for furans, dioxins and chlorinated hydrocarbons were carried out by the Ministry of the Environment laboratories.

3.0 THE TEST PROGRAMME

3.1 INTRODUCTION

The programme was divided into two major segments. The first consisted of a series of short tests during which the operation of the plant was monitored and the emissions of combustion products were measured. The intent was to determine how the plant could best be operated to achieve good combustion conditions which would result in minimum emissions of dioxins and furans. The second part of the testing programme was designed to determine the achieved level of dioxin and furan emissions and to identify the ideal operating conditions for the reduction of emissions.

Early examination of the unit's performance showed that many of the factors affecting plant performance could not be completely controlled and were subject to variations, mostly related to the feed composition and quality. These fluctuations in operating conditions implied that each emission test should be of as short a duration as possible in order to avoid their undue influence during the test period. It also indicated that more than the two or three test runs originally envisaged would be needed to obtain statistically significant results which could be used for predictive purposes.

It was decided that a target of 16 test runs should be adopted in an effort to obtain sufficient information for predictions to be made. The low concentrations of the contaminants in the flue gases as well as the limits of detectability of the analyses for dioxins and furans

set a minimum sampling time for each test of 4 1/2 hours. The practicalities of running such tests then indicated that a maximum of four runs per week could adequately be handled. A four-week programme was therefore decided upon for this stage of the tests, with additional time needed to carry out the laboratory work and to analyze the data.

The complexity of monitoring the conditions, handling sampling trains and the samples resulted in the contracted cost of the full programme being approximately \$500,000, exclusive of the costs of sample extraction, clean-up and analyses.

Control of the programme has been under the direction of a Process and Combustion Committee comprising representatives of the Ministry, the Regional Council and Tricil. The Committee is supported by a Testing and Protocol Committee which is responsible for the procedures followed by the sampling and analytical teams. Both these Committees report in turn to a Long-Term Options Committee and a Liaison Committee which jointly represent senior management of the Region, the Ministry of the Environment and the Ministry of Energy.

3.2 OBJECTIVES

The objectives of this programme were:

- a. To review the plant operations and procedures;
- b. To investigate how operating parameters affect combustion in the unit;
- c. To determine the performance of the unit, under various operating parameters, with respect to combustion and emissions;
- d. To analyze the data, report on all of the above and provide recommendations to the Long-Term Options and Liaison Committees as to the best methods of operating the unit in order to minimize emissions of dioxin and furans, smoke and particulates.

These objectives were also those provided to Envirocon, with the exception of providing recommendations to the senior committees.

3.3 FIELD TASKS

To meet these objectives, four basic field tasks were identified:

- a. Pre-testing - to identify operational parameters, to identify additional equipment or operations needed to enable subsequent tasks to be performed satisfactorily,
- b. Cold Flow Tests - to obtain information on flow patterns within the unit and the general effects of combustion air distribution on these patterns,
- c. Diagnostic Tests - to monitor the effects of operational changes and other parameters on emissions of dioxins, furans, their precursors and particulates.

All these tests were conducted on the Number 1 boiler. Neither the Number 2 boiler nor the turbine-generator was in operation during the tests.

3.4 INSPECTION AND COLD TESTS

Inspection of the boiler indicated that:

- a. Holes in the grate, intended to allow the access of combustion air to the deposited burning refuse and ash, were plugged to an unacceptable degree,
- b. The rear seals of the grate designed to prevent air from bypassing the grate were seized in the open position,
- c. The wind-swept spouts through which the feed is distributed over the grate had been modified in a manner which resulted in uneven air distribution,

- d. Heavy dust and ash build-ups were found in the over-fire air jets and plenum, in the flues leading to the electrostatic precipitator and in the lower section of the combustion air heater.

The grate holes, the air plenums and jets were subsequently cleaned and the rear seals were brought to an operational condition. During the balance of the programme only the grate holes showed a gradual build-up of deposits while the air lines remained clear. Dust build-up in the precipitator flues was removed at weekly intervals and the seals were maintained in operating condition by weekly servicing.

The cold tests indicated that gas flow channelling existed. This was reduced by the use of over-fire air. A stagnant zone (which existed when over-fire air was not used) was also eliminated by the use of the rear over-fire air ports. These tests were not necessarily indicative of actual conditions during hot combustion runs, but they do show that the use of over-fire air reduces the risk of both channelling and the formation of stagnant zones.

3.5 COMBUSTION TESTS

Many process and equipment problems arose during the combustion tests and it became apparent that, despite the best efforts of the operators, the control of the feed supply needed to obtain steady boiler operation and steam production was beyond the capability of the system. Handling of the raw waste was complicated by balling, tumbling and bridging of materials on the feed conveyors to the hammer mills, while the pulverized feed conveyors created flow continuity problems. Where possible, modifications were made to alleviate the troubles but they were not completely effective in eliminating feed interruptions.

Other difficulties were presented by control of the steam pressure, which also affected the accuracy of steam flow measurements. With the generator out of service, the only control of steam pressure was by means of a pressure relief valve which could not, despite adjustments, be made to perform satisfactorily in automatic mode. The valve was, therefore, operated manually with resultant pressure fluctuations.

Although the units were designed for a nominal 105,000 lb. per hour of steam production, the actual maximum steam output was found to be in the order of 80,000 lb. per hour. Discussions with the operating staff indicated that 40,000 lb. per hour of steam was the generally accepted minimum attainable load for prolonged operation. After trials had shown that intermediate loads could not be maintained at a consistent level of operation, it was decided to conduct tests at two nominal levels - 50,000 and 70,000 lb. per hour. During the tests, the actual maximum level achieved for sustained operation was 80,000 lbs. steam per hour.

During these runs, under-fire air and over-fire air were varied and it was found that when under-fire air flow rates were selected by the operator, high excess air levels occurred. Adjustments were made during the run, but they never completely eliminated this problem. The rear grate seals were frequently found to be frozen in the open position, thereby permitting air to by-pass the grates. In this situation the fuel bed is disturbed by the by-passing air and burning conditions are adversely affected. The use of over-fire air through the lower back ports appeared to offer the best furnace conditions, with a reduced occurrence of pile build-ups at the back of the grates.

These piles occurred frequently throughout the runs. They affect air distribution and ash burnout and are generally accompanied by increased emissions of smoke, hydrocarbons and carbon monoxide.

The locations of test positions, for temperature probes and for gas and particulate sampling ports, are shown in the attached diagram of the isometric drawing of the plant.

In addition to the instrumentation, special viewing ports were installed at three grate level locations and later at two higher locations. These were designed to permit viewing of furnace conditions without the admission of air which would have affected furnace drafts and performance.

4.0 DIAGNOSTIC TESTS FOR DIOXIN AND FURAN FORMATION

These test runs were carried out under similar conditions and showed similar operational problems to those encountered during the combustion tests. The test runs, however, were longer and covered the time required by ORF to take simultaneous samples of the flue gas for dioxins and furans and for chlorinated organic compounds, potential precursors of the dioxins and furans. These samples were taken by traversing the stack with each train. The methods used for sampling and analysis are described in a separate report (ARB-02-84-ETRD), as are the immediate results of the tests. Basically the sampling was by a modified Ontario Source Testing Code Method 5 type train containing fluorisil tubes after the impingers and analysis was by mass spectrometer after the desired components of the sample had been extracted and purified by commonly agreed and accepted procedures.

In addition to flue gas samples, other samples were taken by ORF from the bottom ash, fly ash, grate ash and feed. Throughout the runs temperature readings, gas composition analyses and flow measurements were taken by Envirocon in the same manner as was used for the combustion tests. The apportionment of the total gas flow through the boiler into over-fire air, under-fire air, feed chute and infiltration was made using injection of Helium as a tracer gas into the individual air streams.

5.0 COMBUSTION TEST RESULTS

Full details of the tests and test results are given in Report ARB-43-84-ETRD produced by Envirocon. In summary, they indicate that the unit is subject to frequent disturbances due primarily to feed rate control problems, accentuated by control instrument problems such as steam pressure control.

Further mechanical problems arise from the grate seals, grate blockages and dust fall-out in the exhaust ducts. These factors disrupt the combustion conditions. In addition to mechanical problems, the quality of feed material is variable with regard to combustion characteristics and size distribution which, although not abnormally variable, can affect stabilization of operation.

Though simple linear correlations have been calculated for many parameters, there are no statistically significant simple correlations other than one between furnace temperatures and steam production rates. Indications, however, are that increased use of over-fire air reduces emissions and that excessive total air supply results in increased emissions.

A fairly good correlation exists between particulate emissions from the stack and gas flow through the electrostatic precipitator. At high steam production rates gas flows and emissions are generally high. At these higher production rates, the gas flows exceed those for which the precipitator was designed. Nevertheless emissions of suspended particulate were always within the maximum permitted by the impingement standard.

In general, the bottom ash quality has been good with low calorific value indicating good burn-out of the ash although large pieces of unburnt material could occasionally be seen in the ash. The quality of the precipitator ash, on the other hand, has been variable with respect to its combustible content indicating variable combustion conditions with incomplete burn-out in the gas phase.

Combustion or incineration efficiency has been calculated from the evidence of two runs to be between 99.15% and 99.69%, although wider variations may occur. The boiler thermal efficiency is of the order of 50%.

Conclusions

The following conclusions may be drawn from these results:

- a. Combustion efficiency is relatively low;
- b. Combustion efficiency can be improved by the use of over-fire air to a limited degree;
- c. Combustion efficiency can be improved by the use of reduced combustion air flows (less excess air);

- d. Combustion efficiency is improved at higher feed rates and higher furnace temperatures;
- e. Improved performance would be achieved with suitable modifications to the refuse/feed handling and shredding operations. A major re-design may be needed if it is decided that feed improvements are required.
- f. Stabilized operation will require improved steam pressure control, over-fire and under-fire air control systems.

6.0 DIAGNOSTIC (DIOXIN) TEST RESULTS

All results obtained for the dioxin and furan tests indicate that, for the conditions employed during these tests, dioxin and furan emissions were within the provisional guidelines established for these compounds (see attached table) and that two units could satisfactorily have operated simultaneously under these conditions. For one test result (test 25-1) the emissions from two units would have been only marginally within the guideline. However, the average of the test results indicate that $190 \text{ pg/m}^3 \pm 100 \text{ pg/m}^3$ is the general range of results.

No reason has yet been established for the high level of emissions during the test 25-1. A major difference from all but one other test (26-1) is the high level of chlorophenols in the feed material (2,000 ng/g). Chlorophenols are believed to be precursors in the formation of dioxins.

The feed material for all other tests contained less than 750 ng/g of chlorophenols. The scatter of results among these tests was too large for a significant correlation to be found between chlorophenols in the feed and the emissions of dioxins.

The body of the Envirocon report, in addition to commenting on the tests and the test results, indicates that the general condition and maintenance of the equipment was such as to cause "a number of delays and was not conducive to maintaining consistently good furnace performance". Existing instrumentation for monitoring the unit's

performance and its operations is also inadequate. The absence of adequate written operating instructions to ensure consistent operating procedures limited the ability to achieve steady maintenance of conditions throughout a test run.

7.0 RECOMMENDATIONS

The following recommendations have been made to the Long-Term Options Committee:

- a. The Solid Waste Reduction unit now be allowed to operate at rates of up to 80,000 lb. per hour steam production per unit, under the operating conditions established during the test period;
- b. The restriction limiting SWARU to 4 days a week operation now be removed;
- c. The Long-Term Options Committee consider, in principle, modifications to the unit to improve the feed system and the boiler control equipment as well as the addition of other emission control equipment to replace or improve the existing electrostatic precipitator.

8.0 PROPOSED CONDITIONS OF OPERATION

- a. A maximum steam production rate of 80,000 lb. per hour per unit (equivalent to a design feed rate of 240 tons per day per unit) be established;
- b. Detailed operating instructions be prepared giving procedures to be followed;
- c. A detailed maintenance programme, acceptable to the Director, West Central Region of the Ministry of the Environment, be instituted dealing with grate and grate seal overhauls on a regular basis, the use of soot blowers, a schedule for changing hammers in the waste shredders and any other items mutually agreed by the Ministry of the Environment and the

Regional Municipality;

- d. Instrumentation to permit monitoring of the combustion air distribution be installed
- e. Instrumentation to permit monitoring of combustion performance (e.g. carbon monoxide measuring instruments in the off gas system) be installed
- f. Over-fire air be used at all times
- g. An operating log and/or an instrument recording system, acceptable to the Director, West Central Region of the Ministry of the Environment, be in place to record operating and monitoring parameters and to record maintenance work;
- h. A regular report on operating conditions and maintenance be made available to the Director, West Central Region in a form and at a frequency acceptable to him;
- i. A firm plan be developed for the installation of additional control equipment to remove particulate matter from the exhaust gases.

9.0 FUTURE ACTIONS

The analysis of the Combustion Testing Programme at the SWARU plant, as discussed in preceding sections of this report, has provided key information. This information will be used to assist in the formulation of both short and long-term options respecting SWARU's role as a component of the Regional Municipality of Hamilton-Wentworth's waste management system. Results during the testing programme indicated that a further examination of the particulate emission problem is needed to assist in finalizing a sound plan of action. Other factors (such as the remaining life of the SWARU plant) as well as other components of the waste management system (transfer stations, landfill), market opportunities for energy and material recovery as well as funding mechanisms (Federal and Provincial assistance programmes) must also be considered.

The following options are suggested for further examination using the studies and results obtained to date.

Short-Term

- . Resume operation of the SWARU plant at the maximum rate as established for safe operation, based on the test conditions (i.e. remove current restriction) but with improved process controls and operating procedures resulting from the test programme as presented in the preceding section "Conditions for SWARU Operation". Operation under these conditions will ensure that the guidelines for dioxin emissions will be met;
- . Initiate an independent review and report by March 31, 1984 on particulate emission control alternatives and their estimated cost, performance and schedule for implementation.

Long-Term

Long-term options for SWARU as a component of Hamilton-Wentworth's waste management system will be formulated by September 30, 1984 looking at the plant under two scenarios:

- A. In isolation and in its present role;
- B. As a component of the total waste management system having different or expanded potential for servicing the area.

Options for the SWARU plant itself include:

- A-1 Modification to the boiler and air emission control equipment (back-end) sections, or;
- A-2 Modification to the back-end sections plus the waste handling and preparation (front-end) sections.

Depending on further analysis, which will be described in the report on particulate control alternatives, A-1 and A-2 are possible long-term options or interim options under scenario B. Expenditures for

option A-1 or A-2 would likely decrease under scenario B in that a lower cost short-term modification could be undertaken which would be more economically acceptable than would be considered in the longer term. Long-term options under B include:

B-1 Improvement of the Hamilton-Wentworth waste management system by optimizing SWARU and addressing:

- a) energy from waste improvements
- b) material recovery
- c) source separation

in a combination to expand on current activities and to minimize landfill.

B-2 Development of new energy from waste and other facilities to realize the maximum potential of these facilities and to demonstrate Hamilton-Wentworth's continued role as a provincial leader in developing modern waste management techniques.

The Ministry of the Environment has a long history of co-operation with the Regional Municipality of Hamilton-Wentworth to realize the maximum potential of SWARU and the other components of its waste management system. The Ministry is committed to continue this co-operation in order that the residents of Hamilton-Wentworth can be served by a modern, effective and environmentally sound waste management system.

SWARU: Process and Combustion Testing

Point of Impingement Concentrations

(2 Units Assumed to be online)

Test No.	Equivalent (1) Dioxin Emissions ug/sec	Stack Temp °C	Exit Gas Rate m ³ s	Critical Wind Speed m/s	Maximum Ground Level Concentration pg/m ³
21-1	42.9	282	34.9	3.5	185
4-1	30.0	250	27.4	2.6	172
5-1	56.4	303	36.6	3.8	226
6-1	81.5	316	39.2	4.1	301
10-1	53.0	299	36.9	3.8	212
11-1	21.0	311	39.8	4.2	77
12-1	40.8	324	44.7	4.7	131
13-1	33.5	272	36.3	3.6	140
17-1	23.9	302	38.0	3.9	92
19-1	40.2	270	34.4	3.4	178
24-1	22.9	320	43.6	4.6	76
25-1	128.6	323	41.4	4.5	446
26-1	48.2	257	30.4	3.0	246
Average	47.9	295	37.6	3.8	191 ⁽²⁾
Range	21.0-128.6	250-324	27.4-44.7	2.6-4.7	77-446

Note:

Concentrations from a single unit would be about 85-90% of these values.

Maximum concentration occurs at 1217m from stack

(1) Equivalent dioxin emissions equals dioxin emissions + 1/50 x (furan emissions); hence maximum ground level concentrations are directly comparable with MOE provisional guideline of 450 pg/m³ (1/2 hr. Avg).

(2) Standard deviation was ± 100 pg/m³

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HEATED PROPORTIONALLY
MANIFOLD

ELECTROSTATIC
PRECIPITATOR

EXHAUST PATH

never

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234L

COMBUSTION
LABORATORY

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FURNACE

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11

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1302

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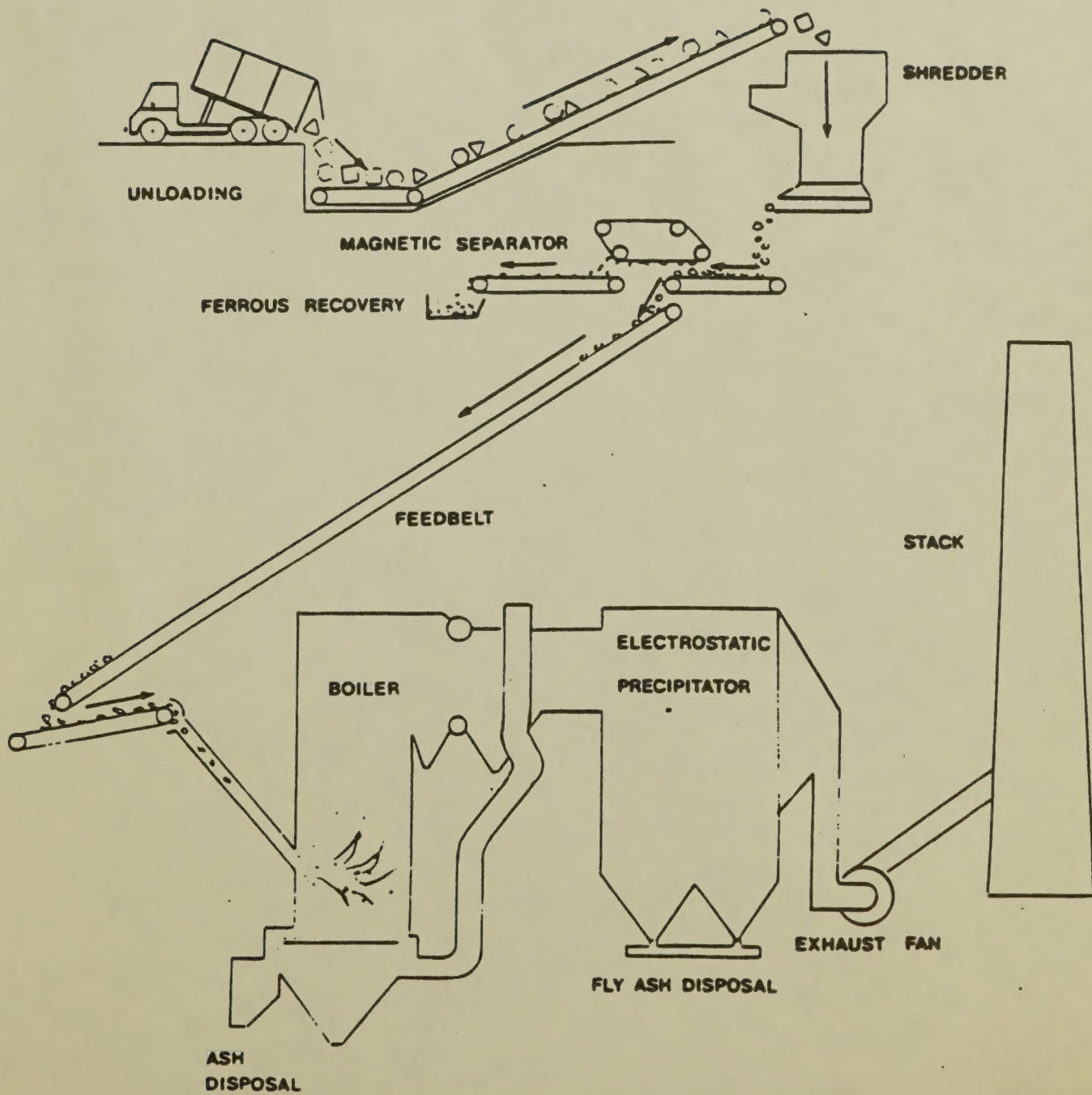
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Process Schematic



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